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METHOD FOR TREATING GASES
CONTAINING FLUOROCOMPOUNDS

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[There are no amendments to the patent.]

Abstract

Problem

To present a method and a catalyst with which gases containing fluorocompounds such as C_2F_6 , etc., are efficiently treated and decomposed.

Solving means

Contacting a gas flow containing a compound containing a fluorine atom and at least 2 carbons such as C_2F_6 , and/or which contains a compound containing a nitrogen atom and a fluorine atom, with a catalyst containing at least one of either alumina, titania, silica, or zirconia, at a temperature between about 400°C and about 800°C , in the presence of an effective amount of water vapor, and converting the F in said gas flow to HF.

Effect

A gas containing a fluorocompound can be efficiently treated for decomposition.

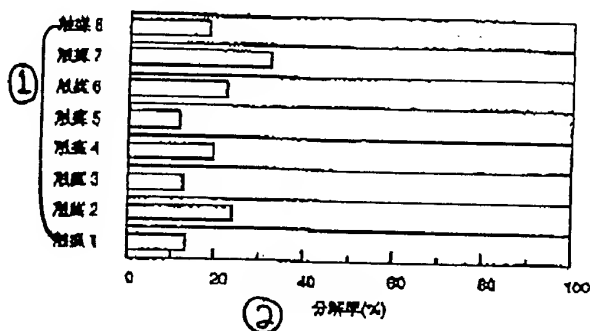


Figure 2

Key: 1 Figure
2 Decomposition rate (%)

Claims

1. A method for treating a gas containing a fluorocompound which includes a process comprising: contacting a gas flow containing a compound containing a fluorine atom and at least 2 carbons and/or which contains a compound containing a nitrogen atom and a fluorine atom; with a catalyst containing at least one variety of either alumina, titania, silica, or zirconia; at a temperature between about 400°C and about 800°C ; in the presence of an effective amount of water vapor; and converting the F in said gas flow to HF.

2. The method for treating a gas containing a fluorocompound in Claim 1, in which said gas containing a fluorocompound is a compound of F and C which contains at least 2 carbons, or is a compound of N and F.

3. The method for treating a gas containing a fluorocompound in Claim 1, in which said catalyst also contains at least one of the following components: Si, Mg, Zr, W, Sn, Ce, Mn, Bi, or Ni.

4. A fluorocompound decomposition catalyst for treating a gas flow containing a compound of F and C containing at least 2 carbons, and/or a compound of N and F; whereby said catalyst contains both alumina and titania, in which the alumina content is 75-98 wt%, and the titania content is 2-25 wt%.

5. The fluorocompound decomposition catalyst in Claim 4, in which said catalyst also contains at least one of the following components: Si, Mg, Zr, W, Sn, Ce, Mn, Bi, Ni, P, or B.

6. The fluorocompound decomposition catalyst in Claim 5, in which said catalyst contains 0.1-10 wt% of oxides of Si, Mg, Zr, W, Sn, Ce, Mn, Bi, Ni, P, or B with respect to the amount of the primary catalyst of alumina-titania.

Detailed explanation of the invention

[0001]

Technical field of the invention

The present invention relates to a method and a catalyst used for efficiently decomposing and treating gases containing fluorocompounds such as C_2F_6 , etc., at low temperatures.

[0002]

Prior art

Gas containing fluorocompounds such as C_2F_6 , etc., are used in large amounts in semiconductor etching materials and for semiconductor cleaning. However, we have learned that these compounds have the property of raising the temperature and causing global warming if they are released to the atmosphere. Strict regulations are expected to be imposed in the future on the treatment of these compounds after they have been used.

[0003]

Gases such as C_2F_6 , etc., contain large amounts of fluorine (F), a molecular structural component. Fluorine has the greatest level of electronegativity of all the elements, and forms extremely stable compounds. In particular, C_2F_6 , etc., are substances with strong internal molecular forces and poor reactivity. Due to this property, high temperatures are required to decompose it, consuming a large amount of energy. Gases such as fluorine gas, etc., which are

generated by these high-temperature decomposition reactions, are very corrosive to apparatus materials, and currently there is no satisfactory method for decomposing and treating these gases.

[0004]

A method for decomposing and treating these gases currently being proposed is a high-temperature combustion technique. However, because this method requires large amounts of fuel it is not very energy efficient. Moreover, it is also problematic in that the furnace walls are damaged by halogen compounds that are produced at 1000°C or above as a result of this combustion. Consequently, there is a need for a technique in which decomposition can be carried out at low temperatures.

[0005]

The use of a TiO_2 - WO_2 catalyst as a catalyst in the decomposition of halogen compounds was previously disclosed in Japanese Kokoku Patent No. Hei 6[1994]-59388. This is a catalyst which contains W in amounts of 0.1-20% of TiO_2 (in atomic ratio, the Ti content is 92%-99.96%, while W is 0.04-8%), and when it is used to treat CCl_4 in amounts on the order of ppm, a 99% decomposition rate at 375°C was maintained for 1500 h. Among the halogen compounds, it is not only Cl compounds that have an effect as a catalyst poison; in fact F compounds have even more of an effect. The patent publication cited above discloses that organic halogen compounds with one carbon atom, specifically, CF_4 and Cl_2F_2 [sic], etc., can be decomposed, however, it includes no application examples of the results of fluorocompound decomposition. Moreover, in general, organic halogen compounds with two carbon atoms do not decompose as readily as organic halogen compounds with one carbon atom. A different example in which an Al_2O_3 - ZrO_2 - WO_3 catalyst is used as a decomposition catalyst for gases containing fluorocompounds is disclosed in Japanese Kokai Patent Application No. Hei 7[1995]-80303. This is a catalyst used in the combustion decomposition of Freon, and when a combustion decomposition reaction was performed at 600°C in the treatment of Freon-115 (C_2ClF_6), a decomposition rate of 98% was maintained for 10 h. Because a hydrocarbon such as n-butane, etc., is added as a combustion auxiliary agent, the treatment costs for this method are high. In addition, it is more difficult to decompose compounds containing fluorine and carbon, such as C_2F_6 , than it is to decompose Freon-115, and no application examples of the results of the decomposition of these compounds were included in this publication.

[0006]

Problem to be solved by the invention

The objective of the present invention is to provide a catalyst and a method whereby a gas containing a compound containing a fluorine atom and two or more carbon atoms, and/or containing a compound of a nitrogen atom and a fluorine atom is treated and efficiently decomposed at low temperatures.

[0007]

Means to solve the problem

The inventors of the present invention achieved the present invention as a result of a detailed study of methods that are able to decompose gases containing fluorocompounds at low temperatures with a high rate of efficiency, and also which do not readily cause corrosion of plant equipment from the hydrogen fluoride that is separated out as a decomposition product.

[0008]

Specifically, it was discovered that by contacting a gas containing a compound containing a fluorine atom and at least 2 carbons and/or which contains a compound containing a nitrogen atom and a fluorine atom with a specific catalyst for decomposing fluorocompounds, at a temperature between about 400°C and about 800°C, in the presence of an effective amount of water vapor, the fluorine contained in the gas flow can be converted to HF. Catalysts that can be used as the decomposition catalyst contain at least one of either alumina, titania, silica, or zirconia.

[0009]

Fluorocompounds include compounds of F and C containing at least two carbons, such as C_2F_6 , etc., or compounds of N and F such as NF_3 , etc.

[0010]

It was also discovered that a gas containing a fluorocompound can be decomposed with a higher degree of activity if at least one of the following components is added to the catalyst: Si, Mg, Zr, W, Sn, Ce, Mn, Bi, or Ni. These catalysts include mixtures or complex compounds containing at least one of the following components: Si, Mg, Zr, W, Sn, Ce, Mn, Bi, Ni, P, or B. The results are especially enhanced with a catalyst containing alumina and titania, in which the alumina content is 75-98 wt%, and the titania content is 2-25 wt%. The effects are also enhanced when the catalyst contains 0.1-10 wt% of oxides of Si, Mg, Zr, W, Sn, Ce, Mn, Bi, Ni, P, or B with respect to the amount of the primary catalyst of alumina-titania.

[0011]

As a result of various studies conducted for the purpose of discovering a catalyst for decomposing gases containing fluorocompounds, it was discovered that a necessary property of the catalyst is that it contain a metallic component which forms an appropriately strong bond with fluorine. In the case of a compound comprised of carbon and fluorine, due to the stability of the molecule itself, it was discovered that catalysts displaying a high degree of decomposition activity were those that contain metallic components in which the fluorine-compound-generating enthalpy is large. Because the fluorocompound cannot be separated from the catalyst if a rather stable bond is formed, the activity gradually decreases. On the other hand, an adequate rate of decomposition is not obtained if the bonding force is too weak. Substances such as C_2F_6 , which is a target substance of the present invention, have the properties of strong intramolecular strength and poor reactivity. It is said that temperatures 1500-2000°C are required to burn these gases. With our investigations, we discovered that the target gas could be decomposed even when alumina, titania, silica, or zirconia was used by itself as the catalyst, however, it was also discovered that it was preferable to use a catalyst that contains both alumina and titania, as a higher rate of decomposition could be obtained. It is thought that alumina has an action which attracts fluorocompounds onto the catalyst, while titania has an action which draws away fluorocompounds from the catalyst.

[0012]

Oxides of Si, Mg, Zr, W, Sn, Ce, Mn, Bi, and Ni are thought to bring about the concerted effects of alumina, titania, silica, and zirconia. They are also thought to contribute to the stabilization of titania in the catalyst.

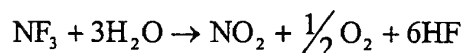
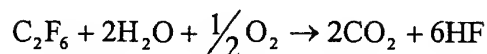
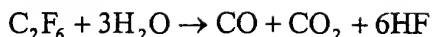
[0013]

In the method for decomposing and treating gas containing fluorocompounds of the present invention, it was also discovered that fluorocompounds such as C_2F_6 , etc., could be diluted with an inert gas. By diluting the fluorocompound concentration, the load with respect to the catalyst is reduced, and the decomposition activity can be maintained for a long period of time. Inert gases that can be used as the diluting gas include Ar, N_2 , He, etc.

[0014]

The fluorine-containing compounds which are the target of the present invention are substances called PFC (perfluorocompounds) or FFC (fully fluorinated compounds such as C_2F_6 and NF_3 , etc. Representative reactions for these are shown below.

[0015]



It is desirable if these fluorocompounds are added in such a way that there are at least as many hydrogen atoms in the gas to be treated as there are fluorine atoms in the fluorocompound. By doing this, the F in the compounds is converted to HF, and the F in the decomposition product is converted to the form of hydrogen halides, which are easily susceptible to posttreatment. Sources of hydrogen that can be used at this time include, in addition to water vapor, hydrogen and hydrocarbons, etc., however, if a hydrocarbon is used, the hydrocarbon is burned by the catalyst, which can reduce the amount of heat energy provided.

[0016]

Furthermore, by having the reaction gas contain an oxide gas such as oxygen, etc., a CO oxidation reaction can also be induced to occur at the same time. If the CO oxidation reaction is incomplete, after the HF in the decomposition product has been removed, the CO can be converted to CO₂ by contacting it with a CO oxidation catalyst.

[0017]

By using the catalyst of the present invention freons such as C₂Cl₃F₃, C₂Cl₂F₄, and C₂ClF₅, etc., Freon substitutes such as HFC134a, etc., and compounds such as SF₆ can be decomposed. Substances such as CCl₃F and CCl₂F₂, etc., can also be adequately decomposed. Moreover, when chlorine compounds are treated, the Cl in the compound is converted to HCl.

[0018]

It is preferred if the reaction temperature used in the present invention is between about 400°C and about 800°C. If a higher temperature is used, although a high rate of decomposition is obtained, the catalyst rapidly degrades. Moreover, the rate of corrosion of the apparatus materials abruptly increases. On the other hand, the decomposition rate is low at temperatures lower than this. In addition, a highly efficient process for neutralizing and removing the HF generated is one in which it is purified by spraying it with an alkaline solution. This method is preferred because blockage of the pipes does not readily occur with such a method. Acceptable methods for

purifying the decomposition product gas include methods in which it is bubbled in an alkaline solution and methods in which a packed column is used.

[0019]

Raw material sources of Al for preparing the catalyst of the present invention that can be used include γ -alumina, and a mixture of γ -alumina and δ -alumina, etc. A particularly preferred method is one in which boehmite, or the like, is used as the raw material source of aluminum, and in which an oxide is formed as a result of the final combustion.

[0020]

Raw material sources of Ti for preparing the catalyst of the present invention that can be used include titanous sulfate, titania sol, and titanium slurry, etc.

[0021]

Raw material sources for the third metal component (Si, Mg, Zr, etc.) that can be used include nitrates, aluminum salts and oxides, etc., of each of these metals.

[0022]

Any method used to manufacture ordinary catalysts including precipitation methods, impregnation methods and kneading methods, etc., can be used to manufacture the catalyst of the present invention.

[0023]

The catalyst in the present invention can be used as is in granular form or it can be formed into a honeycomb shape, etc. Any method that meets the objective can be used as the forming method, including extrusion forming methods, tablet-forming methods, and roll-granulation methods, etc. A metallic or ceramic honeycomb or plate can also be coated and used.

[0024]

The method for treating gases containing fluorocompounds of the present invention is able to decompose fluorocompounds at lower temperatures than other treatment methods.

[0025]

A problem that occurs when a gas containing a fluorocompound is treated is corrosion of the apparatus materials from the acid components of HF, etc., produced by the decomposition.

However, as a result of the present invention, because the temperatures used are comparatively low, the rate of corrosion is slowed, and maintenance of the apparatus becomes unnecessary.

[0026]

The apparatus used to implement the method for treating gases containing fluorocompounds of the present invention may consist solely of a catalyst reaction tank in which the fluorocompounds are decomposed, and a facility for neutralizing and removing acid components in the decomposition product gas, so the apparatus can be reduced in size.

[0027]

Embodiments of the invention

The present invention is explained in further detail below using application examples. The present invention is not limited to these application examples.

[0028]

Figure 1 shows an application example of the method for decomposition treatment of the present invention when it is used in a process for cleaning a plasma CVD apparatus used in a process for manufacturing semiconductors.

[0029]

A plasma CVD apparatus is a device with which a SiO_2 film is formed on the surface of a semiconductor wafer by chemical vapor deposition. However, because the SiO_2 film adheres to all surfaces inside the device, SiO_2 must be removed from places where it is not needed. C_2F_6 is used to clean off this SiO_2 . A cleaning gas containing C_2F_6 is fed into the CVD chamber where it is excited by the plasma and the SiO_2 is removed. The chamber interior is then replaced with N_2 , the C_2F_6 concentration is diluted to about 3-5%, and exhausted from the chamber at a rate of about 15 L/min.

[0030]

Air 3 is added to this exhaust gas to dilute the C_2F_6 . Water vapor 4 is added to this diluted gas to form a reaction gas 5 which is sent to the decomposition process. The C_2F_6 concentration in the reaction gas is about 0.5%. In the decomposition process, the reaction gas 5 is contacted with an Al_2O_3 catalyst at 700°C at a space velocity of 3000 per hour (space velocity (h^{-1}) = reaction gas flow rate (mL/h)/catalyst amount (mL)). In this case the reaction gas may be heated and the catalyst may also be heated with an electric furnace or the like. The decomposed gas 6 is sent to an exhaust gas cleaning process. In the exhaust gas cleaning process, an alkaline aqueous

solution is sprayed into the decomposed gas 6, and exhaust gas 7, from which the acid component in the decomposed gas 6 has been removed, is released outside the system. The C_2F_6 decomposition rate is calculated by analyzing the reaction gas 5 and the exhaust gas 7 using an FID (flame ionization detector) gas chromatograph and a TCD (thermal conductivity detector) gas chromatograph, calculated according to the mass balances at the inlet and outlet.

[0031]

The results of an investigation of the activity of various fluorocompound decomposition catalysts are explained below.

[0032]

Application Example 1

Air was added to C_2F_6 gas of at least 99% purity to dilute it. Water vapor was added to this diluted gas. The water vapor was formed by feeding pure water at a rate of 0.11 mL/min in to the top of a reaction tube, using a microtube pump, and vaporizing it. The C_2F_6 concentration in the reaction gas was about 0.5%. This reaction gas was contacted at a space velocity of 3000 per hour with a catalyst that had been heated to 700°C using an electric furnace from the outside of the reaction tube.

[0033]

The reaction tube is a reaction tube made of Inconel with a 19 mm inside diameter. The catalyst layer is contained in the center of the reaction tube, and a thermocouple protective tube made of Inconel with a 3 mm outside diameter is provided on the inside of the reaction tube. The decomposition product gas which has passed through the catalyst layer is bubbled in an aqueous solution of sodium hydroxide, and is released outside the system. The C_2F_6 decomposition rate was calculated by FID gas chromatograph and TCD gas chromatograph using the formula below.

[0034]

[Mathematical formula 1]

$$\text{Decomposition rate} = 1 - \frac{\text{Fluorocompounds at outlet}}{\text{Fluorocompounds supplied}} \times 100 (\%)$$

(Mathematical formula 1)

[0035]

The methods for manufacturing each of the catalysts provided for the tests conducted under the conditions described above are shown below.

[0036]

Catalyst 1: Al_2O_3

Granular alumina produced by Sumitomo Chemical (NKHD-24) was pulverized, sifted to a particle diameter of 0.5-1 mm, dried for 2 h at 120°C, baked for 2 h at 700°C, and then used for testing.

[0037]

Catalyst 2: TiO_2

Granular titania produced by Sakai Kagaku (CS-200-24) was pulverized, sifted to a particle diameter of 0.5-1 mm, dried for 2 h at 120°C, baked for 2 h at 700°C, and then used for testing.

[0038]

Catalyst 3: ZrO_2

200 g zirconyl nitrate was dried for 2 h at 120°C, then baked for 2 h at 700°C. The powder obtained was put into a mold and press molded at a pressure of 500 kgf/cm². The molded product was pulverized, then sifted, and granular zirconia was formed into granules with a particle diameter of 0.5-1 mm, which were then used for testing.

[0039]

Catalyst 4: SiO_2

Granular silica produced by Fuji Silysia (CARIAC-10) was pulverized, sifted to a particle diameter of 0.5-1 mm, dried for 2 h at 120°C, baked for 2 h at 700°C, and then used for testing.

[0040]

Catalyst 5: $\text{TiO}_2\text{-ZrO}_2$

Granular titania produced by Sakai Kagaku (CS-200-24) was pulverized to 0.5 mm or less. 78.3 g of zirconyl nitrate were added per 100 g of this powder, and kneading was carried out while adding pure water. After kneading, it was dried for 2 h at 120°C, then baked for 2 h at 700°C. The powder obtained was placed in a mold and press molded at a pressure of

500 kgf/cm². The molded product was pulverized, then sifted to a particle diameter of 0.5-1 mm, and then used for testing.

[0041]

Catalyst 6: Al₂O₃-MgO

Granular alumina produced by Sumitomo Chemical (NKHD-24) was pulverized to 0.5 mm or less. 56.4 g of magnesium nitrate were added per 100 g of this powder, and kneading was carried out while adding pure water. After kneading, it was dried for 2 h at 120°C, then baked for 2 h at 700°C. The powder obtained was placed in a mold and press molded at a pressure of 500 kgf/cm². The molded product was pulverized, then sifted to a particle diameter of 0.5-1 mm, and then used for testing.

[0042]

Catalyst 7: Al₂O₃-TiO₂

Granular alumina produced by Sumitomo Chemical (NKHD-24) was pulverized to 0.5 mm or less. 56.4 g of a dried powder of a metatitanic acid slurry were added per 100 g of this powder, and kneading was carried out while adding pure water. After kneading, it was dried for 2 h at 120°C, then baked for 2 h at 700°C. The powder obtained was placed in a mold and press molded at a pressure of 500 kgf/cm². The molded product was pulverized, then sifted to a particle diameter of 0.5-1 mm, and then used for testing.

[0043]

Catalyst 8: Al₂O₃-SiO₂

Granular alumina produced by Sumitomo Chemical (NKHD-24) was pulverized to 0.5 mm or less. 13.2 g of a dried powder of a sol of SiO₂ were added per 100 g of this powder, and kneading was carried out while adding pure water. After kneading, it was dried for 2 h at 120°C, then baked for 2 h at 700°C. The powder obtained was placed in a mold and press molded at a pressure of 500 kgf/cm². The molded product was pulverized, then sifted to a particle diameter of 0.5-1 mm, and then used for testing.

[0044]

The results of the tests of the aforementioned catalysts 1-8 are shown in Figure 2.

[0045]

Application Example 2

In this application example, the effects of adding the third component were studied under the same conditions used in Application Example 1. Each of the catalysts prepared are as described below.

[0046]

Catalyst 9: $\text{Al}_2\text{O}_3\text{-TiO}_2$

Granular alumina produced by Sumitomo Chemical (NKHD-24) was pulverized, sifted to a particle diameter of 0.5-1 mm, then dried for 2 h at 120°C. This was then impregnated with a 30% aqueous solution of 176 g of titanium nitrate. After impregnation, it was dried for about 5 h at 250-300°C, then baked for 2 h at 700°C. This was then used for testing.

[0047]

Catalyst 10: $\text{Al}_2\text{O}_3\text{-TiO}_2\text{-ZrO}_2$

Granular alumina produced by Sumitomo Chemical (NKHD-24) was pulverized, sifted to a particle diameter of 0.5-1 mm, then dried for 2 h at 120°C. This was then impregnated with a 30% aqueous solution of 176 g of titanium nitrate. After impregnation, it was dried for about 5 h at 250-300°C, then baked for 2 h at 700°C to prepare catalyst A. Then an aqueous solution in which 6.7 g of zirconyl nitrate dihydrate were dissolved in 90 g of H_2O was impregnated into 50 g of catalyst A. After impregnation, it was dried for 2 h at 120°C, then baked for 2 h at 700°C. This was then used for testing.

[0048]

Catalyst 11: $\text{Al}_2\text{O}_3\text{-TiO}_2\text{-WO}_2$

Catalyst A was prepared in the same way as in Catalyst 10. Then, an aqueous solution, in which 6.5 g of ammonium paratungstate were dissolved in 90 g of H_2O , was impregnated into 50 g of catalyst A. After impregnation, it was dried for 2 h at 120°C, then baked for 2 h at 700°C. This was then used for testing.

[0049]

Catalyst 12: $\text{Al}_2\text{O}_3\text{-TiO}_2\text{-SiO}_2$

Catalyst A was prepared in the same way as in Catalyst 10. Then an aqueous solution, in which 7.5 g of a 20 wt% silica sol were dissolved in 90 g of H_2O , was impregnated into 50 g of catalyst A. After impregnation, it was dried for 2 h at 120°C, then baked for 2 h at 700°C. This was then used for testing.

Catalyst 13: Al_2O_3 - TiO_2 - SnO_2

Catalyst A was prepared in the same way as Catalyst 10. Then an aqueous solution, in which 5.6 g of stannous chloride dihydrate were dissolved in 90 g of H_2O , was impregnated into 50 g of catalyst A. After impregnation, it was dried for 2 h at 120°C , then baked for 2 h at 700°C . This was then used for testing.

[0050]

Catalyst 14: Al_2O_3 - TiO_2 - CeO_2

Catalyst A was prepared in the same way as in Catalyst 10. Then an aqueous solution, in which 10.9 g of cerium nitrate hexahydrate were dissolved in 90 g of H_2O , was impregnated into 50 g of catalyst A. After impregnation, it was dried for 2 h at 120°C , then baked for 2 h at 700°C . This was then used for testing.

Catalyst 15: Al_2O_3 - TiO_2 - MnO_2

Catalyst A was prepared in the same way as in Catalyst 10. Then an aqueous solution, in which 7.2 g of manganese nitrate hexahydrate were dissolved in 90 g of H_2O , was impregnated into 50 g of catalyst A. After impregnation, it was dried for 2 h at 120°C , then baked for 2 h at 700°C . This was then used for testing.

[0051]

Catalyst 16: Al_2O_3 - TiO_2 - Bi_2O_3

Catalyst A was prepared in the same way as in Catalyst 10. Then an aqueous solution, in which 7.4 g of bismuth nitrate hexahydrate were dissolved in 90 g of H_2O , was impregnated into 50 g of catalyst A. After impregnation, it was dried for 2 h at 120°C , then baked for 2 h at 700°C . This was then used for testing.

[0052]

Catalyst 17: Al_2O_3 - TiO_2 - NiO

Catalyst A was prepared in the same way as in Catalyst 10. Then an aqueous solution, in which 7.3 g of nickel nitrate hexahydrate were dissolved in 90 g of H_2O , was impregnated into 50 g of catalyst A. After impregnation, it was dried for 2 h at 120°C , then baked for 2 h at 700°C . This was then used for testing.

[0053]

Catalyst 18: $\text{Al}_2\text{O}_3\text{-TiO}_2\text{-BO}_4$

Catalyst A was prepared in the same way as in Catalyst 10. Then an aqueous solution, in which 12.0 g of ammonium borate octahydrate were dissolved in 90 g of H_2O , was impregnated into 50 g of catalyst A. After impregnation, it was dried for 2 h at 120°C , then baked for 2 h at 700°C . This was then used for testing.

[0054]

The activity of catalysts 9-18, described above, as well as that of the catalyst in Application Example 1, is shown in Figure 3.

[0055]

Application Example 3

In this application example, the alumina and titania raw materials were altered to prepare various other catalysts. The activity of these examples was investigated using the same methods as in Application Example 1.

[0056]

Catalyst 19: Al_2O_3

Boehmite powder produced by CONDEA (PURAL SB) was dried for 2 h at 120°C . 200 g of this dried powder were then baked for 0.5 h at 300°C , then the baking temperature was raised to 700°C , and it was baked for an additional 2 h. The powder obtained was put into a mold and press molded at a pressure of 500 kgf/cm^2 . The molded product was pulverized, then sifted to a particle diameter of 0.5-1 mm, and was then used for testing.

[0057]

Catalyst 20: $\text{Al}_2\text{O}_3\text{-TiO}_2$

Boehmite powder produced by CONDEA (PURAL SB) was dried for 1 h at 120°C . 200 g of this dried powder were kneaded with 248.4 g of a 30% titanium sulfate solution while adding about 200 g of pure water. After kneading, it was dried for about 5 h at $250\text{-}300^\circ\text{C}$, then baked for 2 h at 700°C . The powder obtained was put into a mold and press molded at a pressure of 500 kgf/cm^2 . The molded product was pulverized, then sifted to a particle diameter between 0.5-1 mm, and was then used for testing.

[0058]

Catalyst 21: Al_2O_3 - TiO_2

Boehmite powder produced by CONDEA (PURAL SB) was dried for 1 h at 120°C. About 100 g of pure water were added to 200 g of this dried powder and 78.6 g a 30% titania sol to form an aqueous solution which was then kneaded. After kneading, it was dried for about 2 h at 120°C, then baked for 2 h at 700°C. The powder obtained was put into a mold and press molded at a pressure of 500 kgf/cm². The molded product was pulverized, then sifted to a particle diameter of 0.5-1 mm, and was then used for testing. The activity of Catalysts 19-21 were assessed in the same way as in Application Example 1, and the results are shown in Figure 4.

[0059]

Application Example 4

In this application example, the composition of the Al and Ti in Catalyst 20 of Application Example 3 was changed to prepare other catalysts, and the results of assessment of their activity are presented.

[0060]

Catalyst 22: Al_2O_3 - TiO_2

Boehmite powder produced by CONDEA (PURAL SB) was dried for 1 h at 120°C. 100 g of this dried powder were kneaded with 48.8 g of a 30% titanium sulfate solution while adding about 150 g of pure water. After kneading, it was dried for about 5 h at 250-300°C, then baked for 2 h at 700°C. The powder obtained was put into a mold and press molded at a pressure of 500 kgf/cm². The molded product was pulverized, then sifted to a particle diameter of 0.5-1 mm, and was then used for testing.

[0061]

Catalyst 23: Al_2O_3 - TiO_2

Boehmite powder produced by CONDEA (PURAL SB) was dried for 1 h at 120°C. 100 g of this dried powder were kneaded with 82.4 g of a 30% titanium sulfate solution while adding about 120 g of pure water. After kneading, it was dried for about 5 h at 250-300°C, then baked for 2 h at 700°C. The powder obtained was put into a mold and press molded at a pressure of 500 kgf/cm². The molded product was pulverized, then sifted to a particle diameter of 0.5-1 mm, and was then used for testing.

[0062]

Catalyst 24: $\text{Al}_2\text{O}_3\text{-TiO}_2$

Boehmite powder produced by CONDEA (PURAL SB) was dried for 1 h at 120°C. 100 g of this dried powder were kneaded with 174.4 g of a 30% titanium sulfate solution while adding about 70 g of pure water. After kneading, it was dried for about 5 h at 250-300°C, then baked for 2 h at 700°C. The powder obtained was put into a mold and press molded at a pressure of 500 kgf/cm². The molded product was pulverized, then sifted to a particle diameter of 0.5-1 mm, and was then used for testing.

[0063]

Catalyst 25: $\text{Al}_2\text{O}_3\text{-TiO}_2$

Boehmite powder produced by CONDEA (PURAL SB) was dried for 1 h at 120°C. 100 g of this dried powder were kneaded while adding 392 g of a 30% titanium sulfate solution. After kneading, it was dried for about 5 h at 250-300°C, then baked for 2 h at 700°C. The powder obtained was put into a mold and press molded at a pressure of 500 kgf/cm². The molded product was pulverized, then sifted to a particle diameter of 0.5-1 mm, and was then used for testing.

[0064]

The activity of Catalysts 22-25 were assessed in the same way as in Application Example 5, and the results are shown in Figure 5.

[0065]

Application Example 5

This application example is an example of a case in which sulfuric acid is added during preparation of the catalyst.

[0066]

Catalyst 26: $\text{Al}_2\text{O}_3\text{-TiO}_2$

Boehmite powder produced by CONDEA (PURAL SB) was dried for 1 h at 120°C. Added and kneaded with 150 g of this dried powder were 58.8 g of a 30% titania sol solution CS-N produced by Sekigen Agyo [transliteration], and an aqueous solution prepared by diluting 44.8 g of a 97% sulfuric acid solution with 250 mL of pure water. After kneading, it was dried for about 5 h at 250-300°C, then baked for 2 h at 700°C. The powder obtained was put into a mold and press molded at a pressure of 500 kgf/cm². The molded product was pulverized, then sifted to a particle diameter of 0.5-1 mm, and was then used for testing. With the exception that a

space velocity of 1000 per hour was used, the testing conditions were the same as those in Application Example 1. The results of the test showed that an 80% decomposition rate of C_2F_6 was obtained at a reaction temperature of 650°C.

[0067]

Effect of the Invention

As a result of the present invention, gases containing fluorocompounds such as C_2F_6 , NF_3 , etc., can be efficiently decomposed and treated.

Brief description of the figures

Figure 1 is a flow chart showing a treatment process according to an application example of the present invention.

Figure 2 is a graph showing the performance of various catalysts for decomposing fluorocompounds.

Figure 3 is a graph showing the performance of various catalysts for decomposing fluorocompounds.

Figure 4 is a graph showing the performance of various catalysts for decomposing fluorocompounds.

Figure 5 is a graph showing the performance of various catalysts for decomposing fluorocompounds.

Explanation of symbols

- 1.... C_2F_6
- 2.... N_2
- 3....air
- 4....water vapor
- 5....reaction gas
- 6....decomposed gas
- 7....exhaust gas

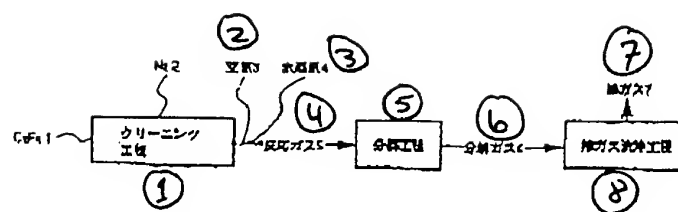


Figure 1

- Key:
- 1 Cleaning process
 - 2 Air
 - 3 Water vapor
 - 4 Reaction gas
 - 5 Decomposition process
 - 6 Decomposed gas
 - 7 Exhaust gas
 - 8 Exhaust gas cleaning process

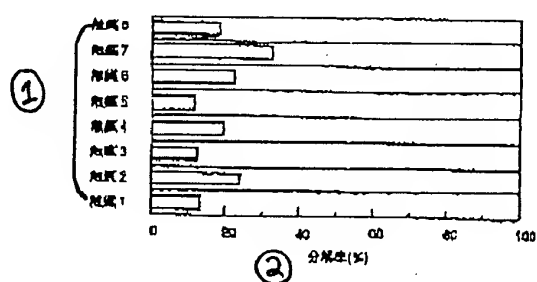


Figure 2

- Key:
- 1 Catalyst
 - 2 Decomposition rate (%)

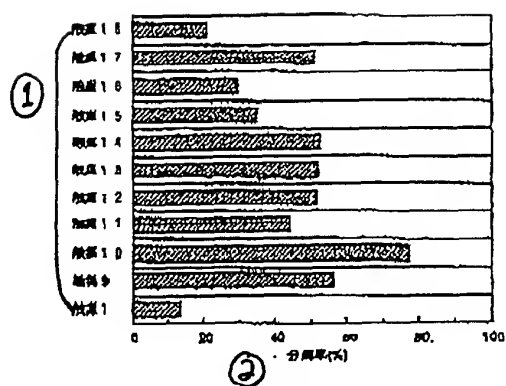


Figure 3

Key: 1 Catalyst
2 Decomposition rate (%)

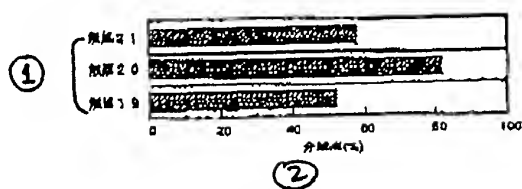


Figure 4

Key: 1 Catalyst
2 Decomposition rate (%)

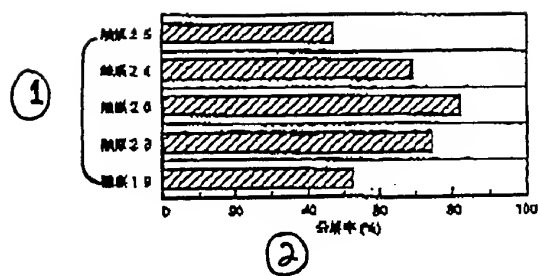


Figure 5

Key: 1 Catalyst
2 Decomposition rate (%)